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Kinne et al.

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(54) **ELECTROSTATIC DISCHARGE CONTROL AND ISOLATION SYSTEM FOR SPRAYING SYSTEMS**

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B05B 9/08	(2006.01)

(52) **U.S. Cl.**
CPC ***B05B 5/1691*** (2013.01); ***B05B 5/1675*** (2013.01); ***B05B 9/0861*** (2013.01)

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CPC ... B05B 5/1616; B05B 5/1625; B05B 15/00; B05B 5/16752; B05B 5/1691; B05B 5/06; B05B 5/08; B05B 5/087; B05B 9/0403; B05B 5/053; B05B 5/00; B05B 5/0255; B05B 5/035; B05B 5/025
USPC 239/525, 526, 302, 375, 378, 690, 691, 239/690.1
See application file for complete search history.

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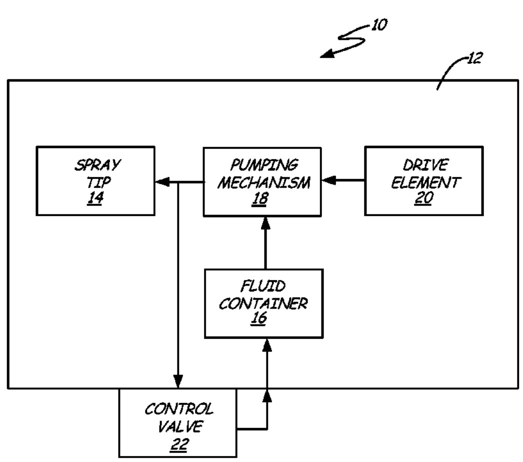
(57) **ABSTRACT**

A fluid dispensing device includes an electrostatic discharge protection system. Accumulation and discharge of electrostatic energy created by operation of the device is reduced or prevented by the electrostatic discharge protection system without an earth ground connection. The electrostatic discharge protection system may include a number of features, such as a static wick, nonconductive components that electrically isolate the spray tip of the device, nonconductive isolation barriers, nonconductive fluid reservoir and suction tube components, a nonconductive coating of a control valve component, and a nonconductive spring retainer of the control valve.

31 Claims, 8 Drawing Sheets



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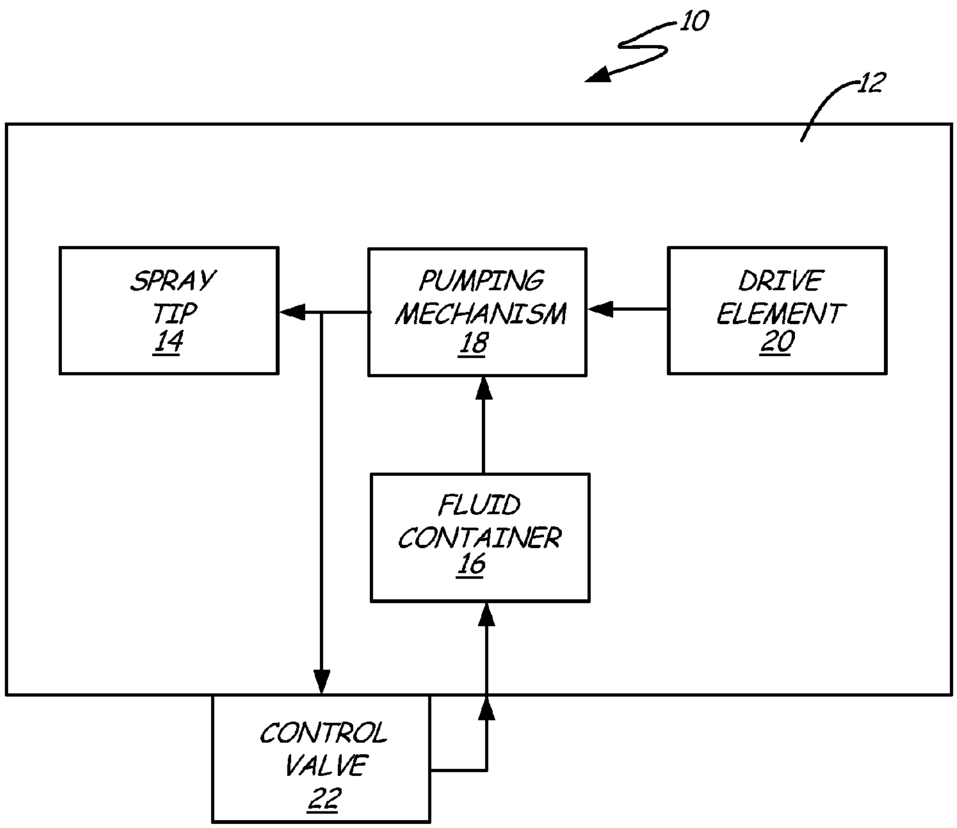
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12
SPRAY TIP 14
PUMPING MECHANISM 18
DRIVE ELEMENT 20
FLUID CONTAINER 16
CONTROL VALVE 22

FIG. 1

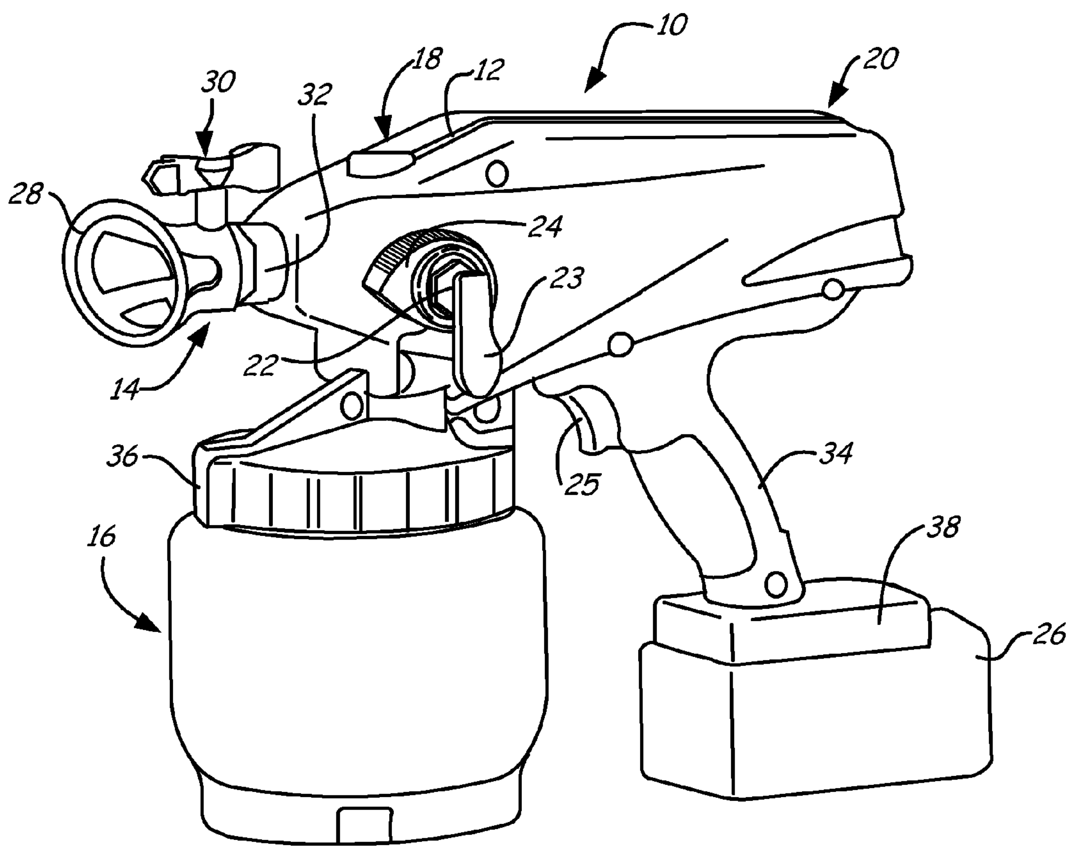

FIG. 2

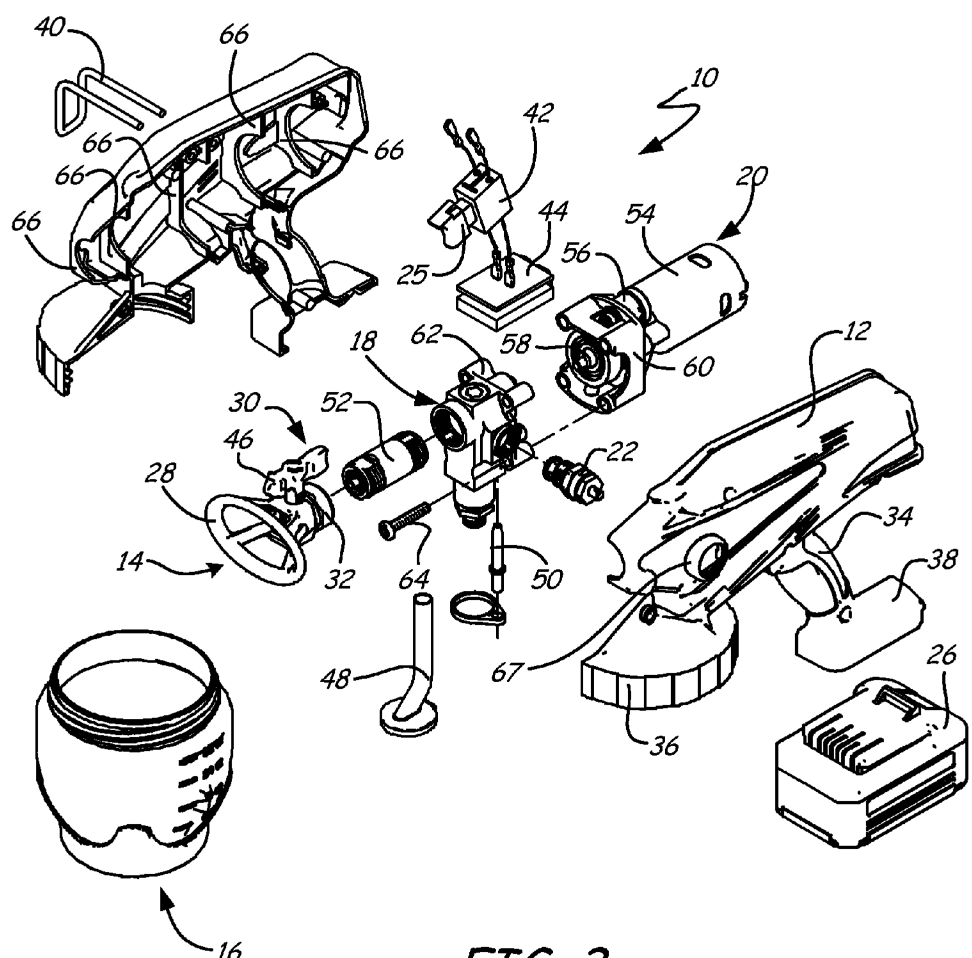
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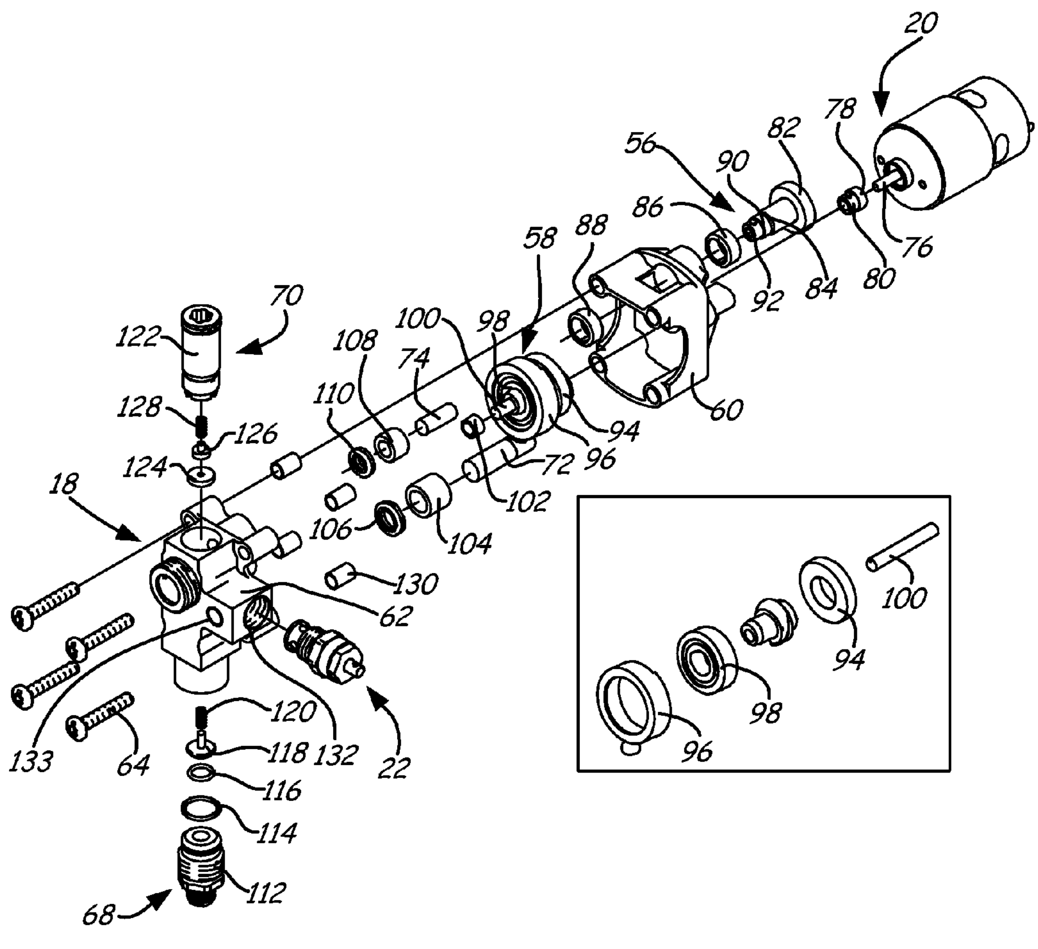
FIG. 3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126
94
96
124
72
102
18
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120
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114
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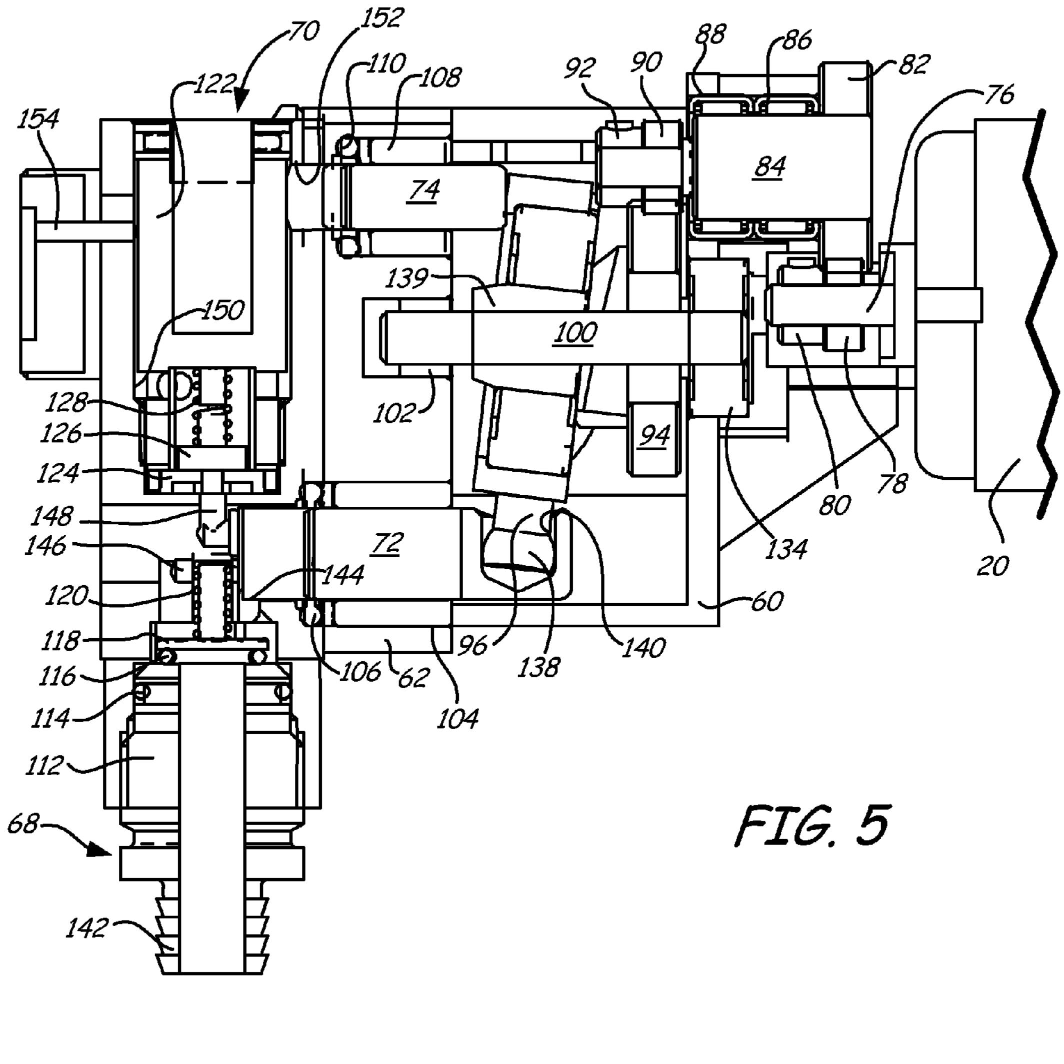
98
94
100

FIG. 4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146
72
144
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96
138
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60
134
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78
20
68
142

FIG. 5

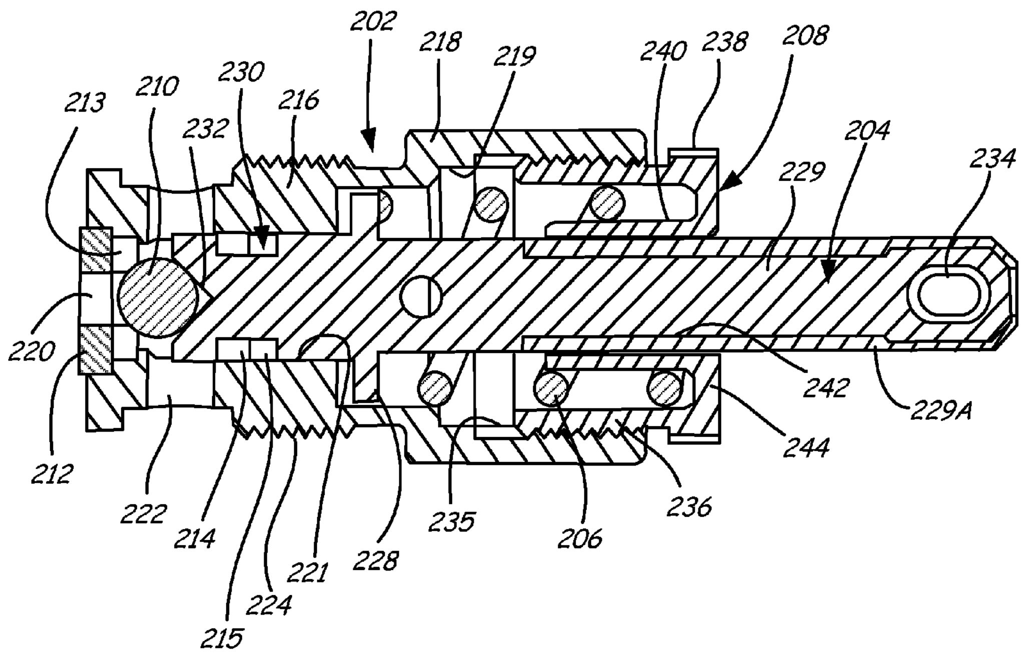
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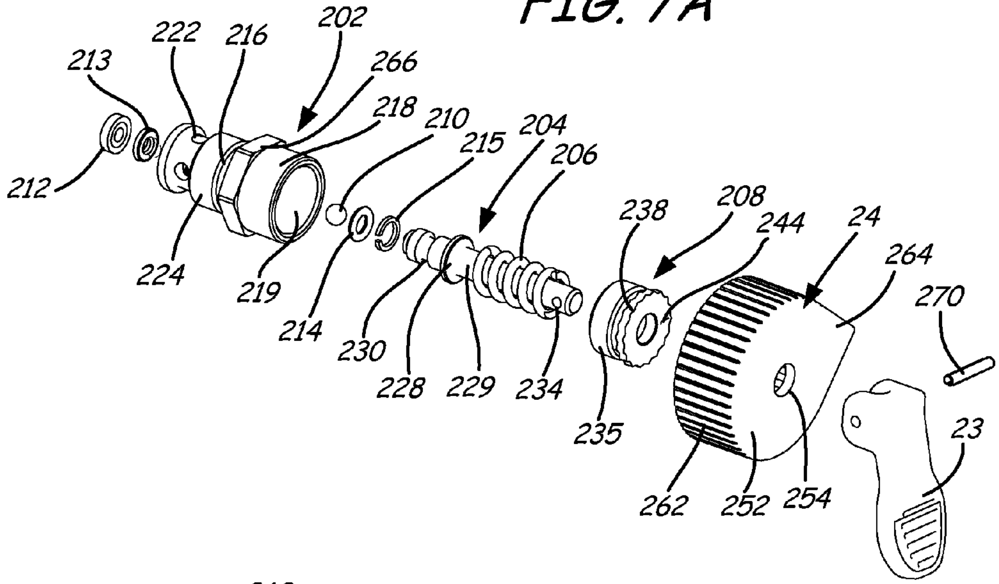
FIG. 6

FIG. 7A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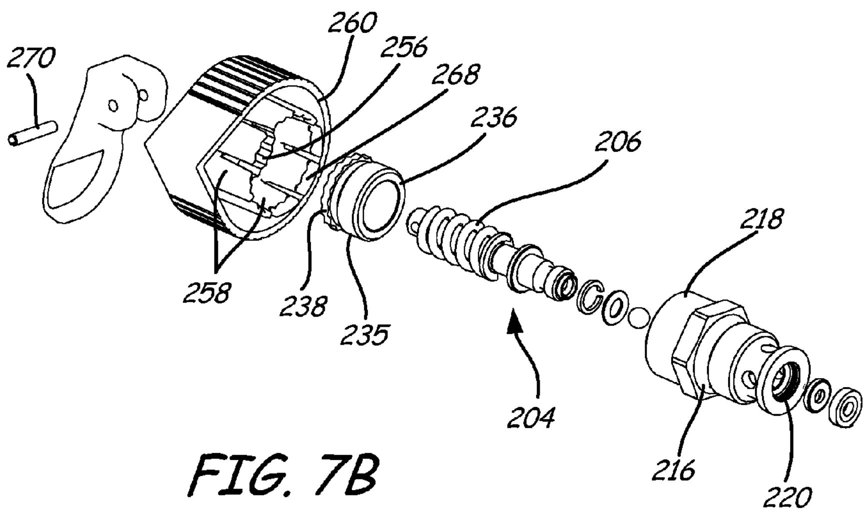
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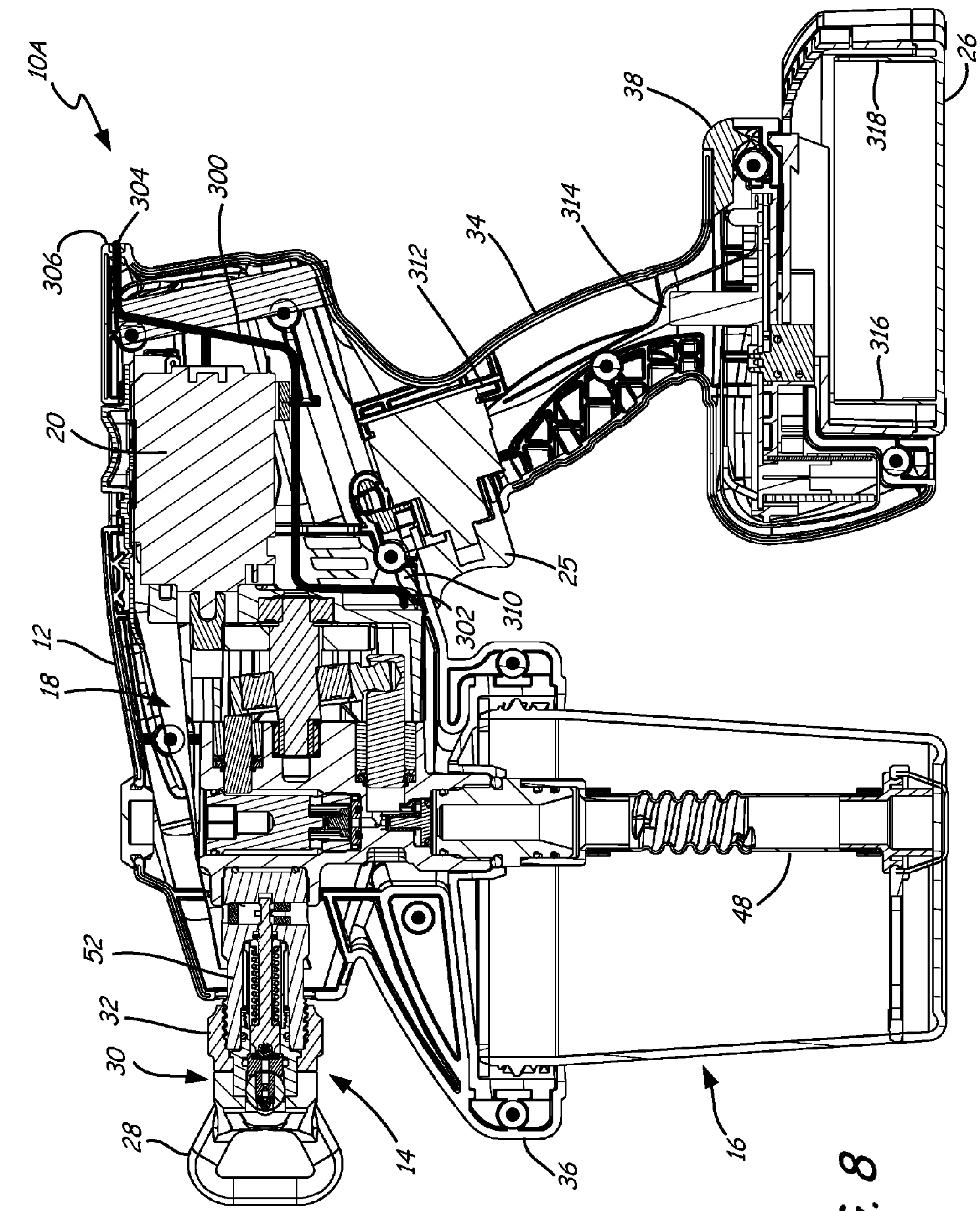
FIG. 7B


10A
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38
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318
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316
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28
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36
16

FIG. 8

ELECTROSTATIC DISCHARGE CONTROL AND ISOLATION SYSTEM FOR SPRAYING SYSTEMS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. application Ser. No. 13/990,715 filed May 30, 2013 for "Electrostatic Discharge Control and Isolation System For Spraying Systems" by Robert W. Kinne U.S. application Ser. No. 13/990,715 is the United States National phase of International Application PCT/US2012/021477, filed on Jan. 1, 2012, which claimed priority to U.S. Provisional Application 61/432,649, filed on Jan. 14, 2011.

BACKGROUND

The present invention is related to liquid dispensing systems. In particular, the present invention relates to spraying devices for dispensing paints, varnishes and the like, and to reducing or preventing the accumulation and/or discharge of electrostatic energy in a paint spraying device.

Paint sprayers are well known and popular for use in painting of surfaces, such as architectural structures, furniture and the like. Paint sprayers provide a high quality finish due to their ability to finely atomize liquid paint. These devices are typically coupled to a paint source, include a pumping mechanism that draws in the paint, and include a small, shaped orifice through which the paint is discharged. Paint sprayers are capable of pressurizing liquid paint to upwards, and in excess of, 3,000 psi [pounds per square inch] (~20.7 MPa).

Moving fluids can generate static-electric potential energy. The quantity of the energy generated can be influenced by any number of factors including, but not limited to, fluid pressure, fluid velocity, fluid composition, method of fluid movement, and source of fluid movement. It is typical in fluid dispensing applications that the equipment be placed in areas that are considered explosive-gas-atmospheres. If the energy generated through fluid movement is allowed to accumulate, it could reach levels at which discharge to ground and subsequent ignition of the explosive atmosphere could occur.

SUMMARY

A fluid dispensing device includes an electrostatic discharge protection system that prevents the accumulation and discharge of electrostatic energy in the device without an earth ground connection. The electrostatic discharge protection system regulates and isolates electrostatic energy to levels that will reduce the risk of igniting explosive atmospheres without a connection to earth ground. This allows for the application of flammable-based materials and coatings with a handheld spraying device.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** shows a block diagram of the main components of an airless fluid dispensing device.

FIG. **2** shows a side perspective view of a handheld sprayer embodiment of the dispensing device of FIG. **1**.

FIG. **3** shows an exploded view of the handheld sprayer of FIG. **2**, showing a housing, a spray tip assembly, a fluid cup, a pumping mechanism, a drive element and the control valve.

FIG. **4** shows an exploded view of the pumping mechanism and drive element of FIG. **3**.

FIG. **5** shows a cross-sectional view of an assembled pumping mechanism and drive element.

FIG. **6** shows a cross-sectional view of a control valve used in the pumping mechanism of FIGS. **3-5**.

FIG. **7**A shows an exploded view of the control valve of FIGS. **2-6** from an exterior perspective.

FIG. **7**B shows an exploded view of the control valve of FIGS. **2-6** from an interior perspective.

FIG. **8** shows a cross-sectional view of a handheld sprayer incorporating an electrostatic discharge protection system having static wick and isolation features for preventing the accumulation and discharge of static energy without an earth ground connection.

DETAILED DESCRIPTION

During operation of fluid handling equipment, energy can be generated in the form of a static-electric potential difference to earth ground. This energy has the ability, and tendency, to accumulate on electrically conductive elements of the device. For cord-connected devices with a main-based power source, this energy can be neutralized through the ground leg of the power supply cable. Fluid handling equipment that is powered by a means that does not offer an immediate ground source can accumulate this energy, eventually reaching levels at which a discharge to ground can occur. The discharge of electrostatic energy, if occurring in an explosive atmosphere, could present a safety hazard.

The present invention protects against electrostatic discharge without a connection to earth ground. This is achieved by providing a static wick that is attached on one end to the energy accumulating elements of the fluid dispensing device. The active end of the static wick is exposed to air. The static wick discharges electrostatic potential energy into the air around its free end.

In addition, nonconductive or insulative barriers or coatings are used to create an increased discharge path between any charged conductive elements and any path to earth-ground. Nonconductive, rather than conductive, components are also strategically placed to electrically isolate conductive elements from each other, therefore reducing the total electric capacitance of the system. Examples of nonconductive elements include the front valve and nut of the spray tip assembly, the reservoir, and the suction tube.

In the following discussion, the design and operation of a portable airless dispensing device such as a paint sprayer will be provided with reference to FIGS. **1** through **7**B, in order to illustrate one example of a dispensing device in which the electrostatic discharge protection can be used. In FIG. **8**, a handheld sprayer generally similar to the paint sprayer of FIGS. **1** through **7**B and incorporating an electrostatic discharge protection system is shown in a cross-sectional view. Static wick and the various isolation and capacitance reduction features of the handheld sprayer are illustrated in FIG. **8** and in FIG. **6**. It should be understood that the electrostatic discharge protection system is applicable to a wide variety of fluid dispensing devices, and is not limited to the specific paint sprayers shown in FIGS. **1** through **8**.

FIG. **1** shows a block diagram of portable airless fluid dispensing device **10**. In the embodiment shown, device **10** comprises a portable airless spray gun comprising housing **12**, spray tip assembly **14**, fluid container **16**, a fluid delivery device formed by pumping mechanism **18** and drive element **20**, and control valve **22**. In various embodiments of the invention, spray tip assembly **14**, fluid container **16**, pumping mechanism **18**, drive element **20** and control valve **22** are packaged together in a portable spraying system. For example, spray tip assembly **14**, fluid container **16**, pumping mechanism **18**, drive element **20** and control valve **22** can each be mounted directly to housing **12** to comprise an integrated handheld device, as described with respect to FIGS. **2** and **3**.

Spray gun **10** comprises an airless dispensing system in which pumping mechanism **18** draws fluid from container **16** and, with power from drive element **20**, pressurizes the fluid for atomization through spray tip assembly **14**. Pumping mechanism **18** comprises, in different embodiments, a gear pump, a piston pump, a plunger pump, a vane pump, a rolling diaphragm pump, a ball pump, a rotary lobe pump, a diaphragm pump or a servo motor having a rack and pinion drive. Drive element **20** comprises, in different embodiments, an electric motor, an air-driven motor, a linear actuator or a gas engine which can be used to drive a crankshaft, cams, a wobble plate or rocker arms. In various embodiments, pumping mechanism **18** generates orifice spray pressure, or running pressure, from about 360 pounds per square inch [psi] (~2.48 MPa) up to about 3,000 psi (~20.7 MPa), or higher. Control valve **22** permits an operator to adjust pressures and flow rates generated by pumping mechanism **18** independent of the speed of pumping mechanism **18**.

FIG. **2** shows a side perspective view of spray gun **10** having housing **12**, spray tip assembly **14**, fluid container **16**, pumping mechanism **18** (FIG. **3**), drive element **20** (FIG. **3**) and control valve **22**. Control valve **22** includes lever **23** and knob **24**. Spray gun **10** also includes trigger **25** and battery **26**. Spray tip assembly **14** includes guard **28**, spray tip **30** and connector **32**. Drive element **20** and pumping mechanism **18** are disposed within housing **12**. Housing **12** includes integrated handle **34**, container lid **36** and battery port **38**.

Fluid container **16** is provided with a fluid that is desired to be sprayed from spray gun **10**. For example, fluid container **16** is filled with a paint or varnish that is fed to spray tip assembly **14** through coupling with lid **36**. Battery **26** is plugged into battery port **38** to provide power to drive element **20** within housing **12**. Trigger **25** is connected to battery **26** and drive element **20** such that upon actuation of trigger **25** a power input is provided to pumping mechanism **18**. Pumping mechanism **18** draws fluid from container **16** and provides pressurized fluid to spray tip assembly **14**. Connector **32** couples spray tip assembly **14** to pump **18**. Tip guard **28** is connected to connector **32** to prevent objects from contacting high velocity output of fluid from spray tip **30**. Spray tip **30** is inserted through bores within tip guard **28** and connector **32** and includes a spray orifice that receives pressurized fluid from pumping mechanism **18**. Spray tip assembly **14** provides a highly atomized flow of fluid to produce a high quality finish. Control valve **22** of the present invention permits an operator to, among other things, open pumping mechanism **18** to atmospheric pressure using lever **23**, and adjust the maximum spray pressure of spray gun **10** using knob **24**.

FIG. **3** shows an exploded view of spray gun **10** having housing **12**, spray tip assembly **14**, fluid container **16**, pumping mechanism **18**, drive element **20** and control valve **22**. Spray gun **10** also includes trigger **25**, battery **26**, clip **40**, switch **42** and circuit board **44**. Spray tip assembly **14** includes guard **28**, spray tip **30**, connector **32** and barrel **46**. Pumping mechanism **18** includes suction tube **48**, return line **50** and valve **52**. Drive element **20** includes motor **54**, gearing assembly **56** and wobble drive assembly **58**. Housing **12** includes integrated handle **34**, container lid **36** and battery port **38**.

Pumping mechanism **18**, drive element **20**, gearing **56**, wobble drive assembly **58** and valve **52** are mounted within housing **12** and supported by various brackets. For example, gearing **56** and wobble drive assembly **58** include bracket **60** which connects to housing **62** of pumping mechanism **18** using fasteners **64**. Valve **52** is threaded into housing **62**, and connector **32** of spray tip **30** is threaded onto valve **52**. Spray tip **30**, valve **52**, pumping mechanism **18** and drive element **54** are supported within housing **12** by ribs **66**. Switch **42** is positioned above handle **34** and circuit board **44** is positioned below handle **34** such that trigger **25** is ergonomically positioned on housing **12**. Switch **42** includes terminals for connecting with drive element **20**, and battery **26** is supported by port **38** of housing **12** in such a manner so as to connect with circuit board **44**. Battery **26** may comprise a Lithium battery, a Nickel battery, a Lithium-ion battery or any other suitable rechargeable battery. In one embodiment, battery **26** comprises a 18 VDC battery, although other lower or higher voltage batteries can also be used. Fluid container **16** is threaded into lid **36** of housing **12**. Suction tube **48** and return line **50** extend from pumping mechanism **18** into fluid container **16**. Clip **40** allows gun **10** to be conveniently stowed such as on a belt of an operator or a storage rack.

To operate spray gun **10**, fluid container **16** is filled with a liquid to be sprayed from spray tip **30**. Trigger **25** is actuated by an operator to activate drive element **20**. Drive element **20** draws power from battery **26** and causes rotation of a shaft connected to gearing **56**. Gearing **56** causes wobble drive **58** to provide an actuation motion to pumping mechanism **18**. Pumping mechanism **18** draws liquid from container **16** using suction tube **48**. Air in the pump, or fluid flow greater than needed, is returned to container **16** through control valve **22** and return line **50**. Pressurized liquid from pumping mechanism **18** is provided to valve **52**. Once a threshold pressure level is achieved, valve **52** opens to allow pressurized liquid into barrel **46** of spray tip **30**. Barrel **46** includes a spray orifice that atomizes the pressurized liquid as the liquid leaves spray tip **30** and gun **10**. Barrel **46** may comprise either a removable spray tip that can be removed from tip guard **28**, or a reversible spray tip that rotates within tip guard **28**. Control valve **22** is inserted through access flange **67** and connected to pumping mechanism **18** to provide 1) a priming valve, 2) a rapid depressurization valve, 3) a safety valve and 4) a pressure adjustment valve.

FIG. **4** shows an exploded view of pumping mechanism **18** and drive element **20** of FIG. **3**. Pumping mechanism **18** includes housing **62**, fasteners **64**, inlet valve assembly **68**, outlet valve assembly **70**, first piston **72** and second piston **74**. Drive element **20** includes drive shaft **76**, first gear **78**, first bushing **80**, second gear **82**, shaft **84**, first bushing **86**, third bushing **88**, third gear **90**, fourth bushing **92** and fourth gear **94**. Wobble drive mechanism **58** includes connecting rod **96**, bearing **98**, rod **100** and sleeve **102**. First piston **72** includes first piston sleeve **104** and first piston seal **106**. Second piston **74** includes second piston sleeve **108** and second piston seal **110**. Inlet valve **68** includes inlet valve cartridge **112**, seal **114**, seal **116**, inlet poppet valve **118** and inlet spring **120**. Outlet valve **70** includes outlet valve cartridge **122**, seat **124**, outlet poppet valve **126** and outlet spring **128**.

Drive shaft **76** is inserted into bushing **80** such that gear **78** rotates when drive element **20** is activated. Bushings **86** and **88** are inserted into a receiving bore within bracket **60**, and shaft **84** is inserted into bushings **86** and **88**. Gear **82** is connected to a first end of shaft **84** to mesh with gear **78**, and gear **90** is connected with a second end of shaft **84** to mesh with gear **94**. Sleeve **102** is inserted into a receiving bore within housing **62** and rod **100** is inserted into sleeve **102** to support wobble drive mechanism **58**. Bearing **98** connects rod **100** to connecting rod **96**. Connecting rod **96**, which comprises a ring with a stud, couples with first piston **72**. First piston **72** and second piston **74** are inserted into piston sleeves **104** and **108**, respectively, which are mounted within pumping chambers within housing **62**. Valve seals **106** and **110** and sleeves **104** and **108** seal the pumping chambers. Fasteners **64** are inserted through bores in housing **62** and bushings **130** and threaded into housing **60**. Inlet valve cartridge **112** is inserted into a receiving bore in bracket **62**. Inlet spring **120** biases poppet valve **118** against cartridge **112**. Similarly, outlet valve cartridge **122** is inserted into a receiving bore in housing **62** such that outlet spring **128** biases poppet valve **126** against seat **124**. Seals **114** and **116** prevent fluid from leaking out of valve **68**, and seat **124** prevents fluid from leaking out of valve **70**. Control valve **22** is inserted into receiving bore **132** in housing **62** to intersect fluid flow from pistons **72** and **74** and to intersect vent **133**. Vent **133** can be positioned on an underside of housing **62** for coupling to return line **50** as shown in FIG. **3**. Control valve **22** is adjustable to permit an operator to manually set the maximum pressure that will be generated within pumping mechanism **18**.

FIG. **5** shows a cross-sectional view of pumping mechanism **18** assembled with drive element **20**. Drive element **20** comprises a mechanism or motor for producing rotation of drive shaft **76**. In the embodiment shown, drive element **20** comprises a DC (direct current) motor that receives electrical input from battery **26**, or another electrical power source. In other embodiments, drive element comprises an AC (alternating current) motor that receives electrical input from a power outlet or a pneumatic motor that receives compressed air as an input. Pumping mechanism **18** comprises a dual piston pump. In other embodiments, pumping mechanism **18** may comprise a double-displacement single piston pump, a gerotor (generated rotor), a gear pump or a rotary vane pump.

First gear **78** is fit over drive shaft **76** and is held in place by bushing **80**. Bushing **80** is secured to shaft **76** using a setscrew or another suitable means. First gear **78** meshes with second gear **82**, which is connected to shaft **84**. Shaft **84** is supported in bracket **60** by bushings **86** and **88**. Gear **90** is disposed on a reduced diameter portion of shaft **84** and secured in place using bushing **92**. Bushing **92** is secured to shaft **84** using a setscrew or another suitable means. Gear **90** meshes with gear **94** to rotate rod **100**. Rod **100** is supported by sleeve **102** and bushing **134** in housings **62** and **60**, respectively. Gears **78**, **82**, **90** and **94** provide a gear reduction means that slows the input to rod **100** from the input provided by drive element **20**.

Rotation of rod **100** produces linear motion of ball **138** of connecting rod **96** through wobble of hub **139**. Ball **138** is mechanically connected to socket **140** of piston **72**. Thus, connecting rod **96** directly actuates piston **72** in both advanced and retracted positions. Piston **72** advances and retracts within piston sleeve **104** in housing **62**. As piston **72** retreats from the advanced position, fluid is drawn into valve **68**. Valve **68** includes stem **142** to which suction tube **48** connects. Suction tube **48** is submerged within a liquid inside fluid container **16** (FIG. **3**). The liquid is drawn into pumping chamber **144** around poppet valve **118** and through inlet **146**. Poppet valve **118** is biased against valve cartridge **112** by spring **120**. Seal **116** prevents fluid from passing between cartridge **112** and poppet valve **118** when poppet valve **118** is closed. Seal **114** prevents fluid from passing between cartridge **112** and housing **62**. Valve stem **118** is drawn away from cartridge **112** by suction produced by piston **72**. As piston **72** advances, fluid within pumping chamber **144** is pushed through outlet **148** toward valve **70**.

Fluid pressurized in chamber **144** is pushed into pressure chamber **150** around poppet valve **126** of valve **70**. Poppet valve **126** is biased against seat **124** by spring **128**. Seat **124** prevents fluid from passing between poppet valve **126** and housing **62** when valve **126** is closed. Poppet valve **126** is forced away from housing **62** as piston **72** moves toward the advanced position, as spring **120** and the pressure generated by piston **72** closes valve **68**. Pressurized fluid from pumping chamber **144** fills pressure chamber **150**, comprising the space between cartridge **122** and housing **62**, and pumping chamber **152**. The pressurized fluid also forces piston **74** to the retracted position. The volume displaced by the advance of piston **72** is larger than the displacement of piston **74**. As such, a single stroke of piston **72** provides enough fluid to fill pumping chamber **152** and maintain pressure chamber **150** filled with pressurized fluid. Additionally, piston **72** has a large enough volume to push pressurized fluid through outlet **154** of housing **62**.

As piston **72** retreats to draw additional fluid into pumping chamber **144**, piston **74** is pushed forward by connecting rod **96**. Piston **74** is disposed within piston sleeve **108** in housing **62**, and piston seal **110** prevents pressurized fluid from escaping pumping chamber **152**. Piston **74** advances to evacuate fluid pushed into pumping chamber **152** by piston **72**. The fluid is pushed back into pressure chamber **150** and through outlet **154** of housing **62**, but is prevented by valve **70** from entering chamber **148**. Piston **72** and piston **74** operate out of phase with each other. For the specific embodiment shown, piston **74** is one-hundred eighty degrees out of phase with piston **72** such that when piston **74** is at its most advanced position, piston **72** is at its most retracted position. Operating out of phase, pistons **72** and **74** operate in synch to provide a continuous flow of pressurized liquid to pressure chamber **150** while also reducing vibration in spray gun **10**. Pressure chamber **150** acts somewhat as an accumulator to provide a more constant flow of pressurized fluid to outlet **154** such that a continuous flow of liquid can be provided to valve **52** and spray tip assembly **14** (FIG. **3**). Receiving bore **132** (FIG. **4**) of housing **62** extends to intersect pressure chamber **150**. Control valve **22** is inserted in receiving bore **132** and is configured to automatically open when pressures generated by pumping mechanism **18** in pressure chamber **150** exceed a threshold level set by control valve **22** or when manually actuated.

FIG. **6** shows a cross-sectional view of control valve **22** used in pumping mechanism **18** of FIGS. **3-5**. Control valve **22** includes housing **202**, plunger **204**, spring **206**, cap **208**, ball **210**, gasket **212**, seat **213**, O-ring seal **214** and backup ring **215**. Body **202** comprises base **216**, cup **218**, spring bore **219**, inlet bore **220**, stem bore **221**, outlet bore **222** and body threads **224**. Plunger **204** comprises flange **228**, stem **229** with non-conductive coating **229**A, seal seat **230**, ball guide **232** and lever bore **234**. Cap **208** comprises cap threads **235**, outer sleeve **236**, scalloped rim **238**, inner sleeve **240**, which defines valve bore **242**, and end wall **244**.

Using body threads **224**, annular valve body **202** is threaded into receiving bore **132** (FIG. **4**) of housing **62** to intersect pressure chamber **150** (FIG. **5**). Inlet bore **220** is fluidly coupled to pressure chamber **150** and is therefore exposed to the fluid pressure generated by pumping mechanism **18**. Outlet bore **222** extends through body **202** to align with a vent, such as vent **133**, in housing **62** to receive return line **50** (FIG. **3**), which extends into fluid container **16** (FIG. **3**). As such, a complete circuit is formed between fluid container **16**, suction tube **48**, pumping mechanism **18**, pressure chamber **150**, relief valve **22** and return line **50**.

Plunger **204** is inserted into stem bore **221** through cup **218** such that flange **228** is disposed within spring bore **219** and stem **229** extends through and out of cup **218**. Spring bore **219** comprises a larger diameter extension of stem bore **221**. Seat **213** is disposed between housing **62** and body **202** within inlet bore **220**. Gasket **212** is pushed into inlet bore **220** to maintain assembly of seat **213** and ball **210** within valve body **202**. When control valve **22** is fully assembled, ball guide **232** of plunger **204** holds ball **210** against seat **213** to prevent fluid from pressure chamber **150** from passing through inlet bore **220** and into outlet bore **222**. O-ring seal **214** is positioned within seal seat **230** between body **202** and plunger **204** to prevent fluid within bore **222** from entering bore **219** when plunger **204** is retraced from seat **213**. Backup ring **215**, which comprises a split ring or washer, is positioned around valve stem **229** to prevent extrusion of o-ring **214** into stem bore **221**. Spring **206** is positioned within bore **219** to push against flange **228** and cap **208**. Cap threads **235** on outer sleeve **236** of cap **208** are threaded into bore **219** on cup **218** such that stem **229** extends into inner sleeve **240** and through end wall **244**. Cap **208** comprises a spring retainer that puts spring **206** in compression to bias plunger **204** toward seat **213** and housing **62**. As discussed below, knob **24** and lever **23** (shown in FIGS. **2**, **7**A and **7**B) are slipped over valve stem **229**. Knob **24** engages scalloped rim **238** and lever **23** couples to lever bore **234**.

Valve **22** provides priming means for pumping mechanism **18**. Upon initiating a new use of spray gun **10**, before fluid has filled pumping mechanism **18**, it is necessary to purge air from within spray gun **10** before buildup of pressure is possible. Lever **23** (FIG. **1**; FIGS. **7**A & **7**B), which is connected to stem **204** by a pin at bore **234**, can be pushed or pulled by an operator to withdraw plunger away from seat **212** via cam action with face **252** which causes ball **210** to disengage from seat **213**. Thus, upon activation of pumping mechanism **18**, air from within spray gun **10** is displaced by fluid from container **16** and purged from spray gun **10** through vent **133**. Likewise, as fluid begins to flow from container **16**, control valve **22** re-circulates the fluid back to container **16**. When lever **23** is released, valve **52** (FIG. **3**) will open upon appropriate fluid pressure to keep fluid pressure to spray tip **14** consistent.

Valve **22** also provides a means for rapidly depressurizing spray gun **10** after use. For example, after operation of spray gun **10** when drive element **20** has ceased operating pumping mechanism **18**, pressurized fluid remains within spray gun **10**. It is, however, desirable to depressurize spray gun **10** such that spray gun **10** can be disassembled and cleaned. Thus, displacement of lever **23** opens valve **22** to drain pressurized fluid within pumping mechanism to container **16** and to release any stored potential energy within spray gun **10**.

Valve **22** also comprises a safety valve to prevent pumping mechanism **18** from becoming over-pressurized. Depending on the preload setting of spring **206**, plunger **204** will be displaced when pressure within pressure chamber **150** reaches a desired threshold level. At such level, pressure chamber **150** is fluidly connected to bore **222** to allow liquid within pressure chamber **150** to travel into vent **133**. Thus, the liquid is returned to container **16** and can be recycled by pumping mechanism **18**.

Notably, this response also allows the valve to be used as a control for the spraying pressure delivered to tip **14**. Here, cap **208** of valve **22** comprises an adjustment mechanism that permits variation of the compression induced in spring **206**, thereby changing the maximum pressure that can be generated by pumping mechanism **18**. In the embodiment shown, cap threads **235** on outer sleeve **236** engage internal threads on cup **218** to permit cap **208** to be rotated to adjust its position relative to base **216** and flange **228**. In other embodiments, other mechanisms can be used, such as a bimodal button mechanism that adjusts the compression of spring **206** between two settings. In one embodiment, valve **22** can be configured to open up anywhere between 1,000 psi (~6.9 MPa) and 3,000 psi (~20.7 MPa). In the described embodiment, knob **24** (FIG. **1**; FIGS. **7**A & **7**B) is adjusted to rotate outer sleeve **236** within cup **218** to adjust the spring compression.

FIG. **7**A shows an exploded view of control valve **22** of FIGS. **2**-**6** from an exterior perspective. FIG. **7**B shows an exploded view of control valve **22** of FIGS. **2**-**6** from an interior perspective. FIGS. **7**A and **7**B are discussed concurrently. Control valve **22** comprises body **202**, plunger **204**, spring **206**, cap **208**, ball **210**, gasket **212**, seat **213**, O-ring seal **214** and backup ring **215**. Body **202** comprises base **216**, cup **218**, spring bore **219**, inlet bore **220**, outlet bore **222** and body threads **224**. Plunger **204** comprises flange **228**, stem **229**, seal seat **230** and lever bore **234**. Cap **208** comprises cap threads **235**, outer sleeve **236**, scalloped rim **238**, inner sleeve **240**, which defines valve bore **242**, and end wall **244**. Knob **24** comprises end face **252**, stem bore **254**, scalloped ring **256**, pliable fingers **258** and dial **260**. Dial **260** includes grips **262** and indicator **264**. Valve body **202** includes faceted surface **266**.

Outer sleeve **236** of cap **208** is threaded into cup **218** of valve body **202**. Knob **24** is coupled to cap **208** via a spline connection that permits relative axial movement, but that prevents relative rotational movement. Specifically, scalloped ring **256** of end face **252** slide into engagement with scalloped rim **238** of cap **208**. As such, knob **24** is locked into circumferential engagement with cap **208**. With ring **256** and rim **238** engaged, pliable fingers **258** are pushed across cup **218** and over faceted surface **266**. Pliable fingers **258** deflect radially outwardly to hug the radially outer perimeter of faceted surface **266**. However, sufficient force can be used to overcome the force of pliable fingers **258** to rotate fingers **258** circumferentially across surface **266**, or to remove knob **24** axially from cap **208**. Specifically, pliable fingers **258** can be situated into a plurality of preset positions along faceted surface **266**, as discussed below. Axial movement of knob **24** is limited by the retention of the pin **270** and lever **23**.

Pliable fingers **258** provide tactile indications of the position of cap **208** such that an operator can move knob **24** in even increments. In the embodiment shown, faceted surface **266** comprises a hexagonal cross-sectional area providing six flat surfaces and six edges against which pliable fingers **258** engage. Specifically, the interior facing surfaces of pliable fingers **258** include crenellations that are shaped to engage the edges of faceted surface **266**. In the embodiment shown, eight pliable fingers **258** include sixteen crenellations plus an additional eight spaces between the fingers that produce a total of twenty-four positions of pliable fingers **258** relative to faceted surface **266**. In such an embodiment, however, knob **24** is restricted to rotating **270** degrees such that eighteen adjustments, thus, nineteen positions are provided. Indicator **264** provides a visual indication to an operator of the position of cap **208** relative to valve body **202**. Indications can be provided on housing **12** (FIG. **1**) to provide a visual representation of the position of knob **24**, of pressure or of flow.

FIG. **8** is a cross-sectional view of portable airless spray gun **10**A, which is generally similar to spray gun **10** shown in FIGS. **1-7**B and described above. Components in spray gun **10**A that are similar (although not necessarily identical to) components of spray gun **10** are designated with the same reference number. Thus, spray gun **10**A includes housing **12**, spray tip assembly **14**, fluid container **16**, pumping mechanism **18**, drive element **20**, and control valve **22** (which is not shown in FIG. **8**, but which is the same as illustrated in FIGS. **1-7**B). Spray tip assembly **14** includes guard **28**, spray tip **30**, and connector or nut **32**. Nut **32** threads on to front valve **52**.

Housing **12** includes integrated handle **34**, container lid **36**, and battery port **38**. Battery case **26** is plugged into battery port **38** to provide power to drive element **20** so that upon actuation of trigger **25**, pumping mechanism **18** is driven by drive element **20**. Pumping mechanism **18** is similar to the pumping mechanism described with respect to spray gun **10**, and operates in a similar fashion. The fluid being sprayed is contained within fluid container **16**, and is drawn into pumping mechanism **18** through suction tube **48**. Pistons within pumping mechanism **18** reciprocate, and supply the fluid under pressure through front valve **52** to spray tip assembly **14**.

Spray gun **10**A includes an electrostatic discharge protection system that prevents the accumulation and discharge of static energy in sprayer **10**A without an earth ground connection. The system includes several different elements that contribute to preventing the accumulation and discharge of static energy that could pose a safety hazard. A first feature of the electrostatic discharge protection system is static wick **300**, which is a conductive wire connected at first end **302** to the electrostatic energy accumulating element of the paint sprayer. Static wick **300** extends from first end **302** to second end **304**, which is exposed to open air on the exterior of spray gun **10**A. In the embodiment shown in FIG. **8**, second end or tip **304** of static wick **300** extends out of housing **12** through port **306** which is located at the rear end of housing **12**. The location of second end **304** is distant from spray tip assembly **14**, as well as from fluid container **16** and battery **26**, but could be located in any location in other embodiments of the paint sprayer.

Static wick **300** may be formed of a single small diameter wire, multiple wires, or any other conductive geometric object, the purpose of which is to discharge electrostatic energy to the surrounding air rather than through a connection to earth ground. At second end **304**, wick **300** has a geometry designed in a fashion as to maximize the discharge efficiency of the static wick. The purpose of static wick **300** is to discharge electric voltage into the air. Thus, static wick **300** helps to reduce the accumulation of static energy by dissipating static charge which tends to accumulate on electrically conductive elements of paint sprayer **10**A.

A second feature of the electrostatic discharge protection system is provided by the body of front valve **52** and nut **32**, which are formed of nonconductive materials, such as plastic, rather than being metal parts. The use of nonconductive materials to form valve **52** and nut **32** isolates spray tip assembly **14** from pump assembly **18**, prevents conduction of electrostatic energy, and reduces electric capacitance of spray gun **10**A to lower electrostatic energy and maximum possible discharge energy.

A third feature of the electrostatic discharge protection system incorporated within spray gun **10**A is the use of nonconductive barriers to increase discharge travel distance. Examples of nonconductive barriers include barrier **310** located near first end **302** of static wick **300** and pump assembly **18**, barriers **312** and **314** located within handle **34**, and barriers **316** and **318** located within battery compartment **26**.

A fourth feature of the electrostatic discharge protection system is the use of nonconductive material to form fluid reservoir **16** and suction tube **48**. The use of nonconductive materials prevents static conduction and helps to reduce overall electric capacitance of spray gun **10**A.

A fifth feature of the electrostatic discharge protection system is nonconductive coating **229**A and nonconductive spring retainer **208** shown in FIG. **6**. These nonconductive features isolate high voltage within housing **12** from the exterior of spray gun **10**A.

The electrostatic discharge protection system incorporated in spray gun **10**A regulates and isolates electrostatic energy to levels that minimize the risk of igniting flammable gases. This is achieved without a connection to earth ground. This reduces the risk involved in the application of flammable based materials and coatings with a handheld spray device.

While the invention has been described with reference to an exemplary embodiment(s), it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment(s) disclosed, but that the invention will include all embodiments falling within the scope of the appended claims.

The invention claimed is:

1. A handheld fluid dispensing device comprising:
a fluid delivery device;
a spray tip or nozzle for atomizing fluid supplied by the fluid delivery device; and
an electrostatic discharge protection system including at least one of: an electrically conductive static wick having a first end connected to an electrostatic charge accumulating component of the device and a second end exposed to atmosphere; a valve formed of nonconductive material and connected between a pump and the spray tip; a barrier adjacent the fluid delivery device; a plurality of nonconductive components positioned to electrically isolate the spray tip from the fluid delivery device; or, a nonconductive coating on a component of the control valve.

2. The device of claim **1**, wherein the electrostatic discharge protection system includes a valve connected between a pump and the spray tip that is formed of nonconductive material.

3. The device of claim **2**, wherein the electrostatic discharge protection system further includes a nut of nonconductive material that connects the spray tip to the valve.

4. The device of claim **2**, wherein the electrostatic discharge protection system further includes a fluid reservoir for containing fluid to be pressurized and atomized and a suction tube for delivering the fluid from the fluid reservoir to the fluid delivery device, the fluid reservoir and the suction tube being formed of nonconductive material.

5. The device of claim **1**, wherein the electrostatic discharge protection system includes a plurality of nonconductive barriers positioned to increase electrostatic discharge travel distance.

6. The device of claim **5**, wherein the nonconductive barriers include a barrier adjacent the fluid delivery device.

7. The device of claim **5**, wherein the nonconductive barriers include a barrier within a handle portion of the device.

8. The device of claim **5**, wherein the nonconductive barriers include a barrier adjacent to a component of the device on which charge can accumulate.

9. The device of claim **1**, wherein the electrostatic discharge protection system includes a plurality of nonconductive components positioned to electrically isolate the spray tip from the fluid delivery device.

10. The device of claim **1**, wherein the electrostatic discharge protection system is configured to reduce or prevent accumulation or discharge of static energy without an earth ground connection.

11. The device of claim **1** and further comprising:

a control valve connected to the fluid delivery device.

12. The device of claim **1**, wherein the electrostatic discharge protection system includes a nonconductive coating on a component of the control valve.

13. The device of claim **12**, wherein the control valve includes a nonconductive spring retainer, a valve stem and a valve body, and wherein the nonconductive coating is on the valve stem.

14. The device of claim **1**, wherein the electrostatic discharge protection system comprises:

an electrically conductive static wick having a first end connected to a component of the device on which charge can accumulate and a second end exposed to atmosphere; and

a plurality of nonconductive components positioned to electrically isolate the spray tip from the fluid delivery device.

15. The device of claim **14**, wherein the electrostatic discharge protection system further includes a plurality of nonconductive barriers positioned to increase electrostatic discharge travel distance.

16. The device of claim **15**, wherein the electrostatic discharge protection system includes a fluid reservoir for containing fluid to be pressurized and atomized and a suction tube for delivering the fluid from the reservoir to the fluid delivery device, the fluid reservoir and the suction tube being formed of nonconductive material.

17. The device of claim **16** and further comprising:

a control valve connected to the fluid delivery device, wherein the electrostatic discharge protection system includes a nonconductive coating on a component of the control valve.

18. A handheld fluid dispensing device comprising:

a housing;

a fluid container connected to the housing;

a spray tip connected to an end of the housing, wherein the spray tip is configured to atomize fluid;

a fluid delivery device internal to the housing for delivering fluid from the fluid container to the spray tip;

a valve passing through a the housing and connecting the fluid delivery device to the spray tip within the housing;

a power source connected to the housing away from the spray tip, for delivering power to the fluid delivery device;

a trigger connected to the housing for controlling the power source; and

an electrostatic discharge protection system including at least one of: an electrically conductive static wick having a first end connected to an electrostatic charge accumulating component within the housing and a second end exposed to atmosphere; a barrier adjacent the fluid delivery device; a plurality of nonconductive components positioned to electrically isolate the spray tip from the fluid delivery device; or, a nonconductive coating on a component of the control valve.

19. The handheld fluid dispensing device of claim **18**, wherein the plurality of nonconductive components are positioned within the housing.

20. The device of claim **1**, wherein the electrostatic discharge protection system is configured to reduce or prevent accumulation or discharge of static energy without an earth ground connection.

21. The handheld fluid dispensing device of claim **18** and further comprising a handle connected to the housing, wherein the handle is positioned away from the spray tip.

22. The handheld fluid dispensing device of claim **21**, wherein the trigger is located on the handle and is positioned near a connection between the handle and the housing.

23. The handheld fluid dispensing device of claim **18**, wherein the valve is formed of a nonconductive material, electrically isolating the spray tip from the fluid delivery device to prevent conduction of electrostatic energy from the fluid delivery device.

24. The handheld fluid dispensing device of claim **18**, wherein the nonconductive barriers include a barrier adjacent the fluid delivery device.

25. The handheld fluid dispensing device of claim **18**, wherein the nonconductive barriers include a barrier within a handle connected to the housing.

26. The handheld fluid dispensing device of claim **18**, wherein the nonconductive barriers include a barrier adjacent to the power source.

27. A handheld fluid dispensing device comprising:

a housing;

a fluid container connected to the housing;

a spray tip connected to the housing, wherein the spray tip is configured to atomize fluid;

a fluid delivery device within the housing for delivering fluid from the fluid container to the spray tip;

a battery power source connected to the housing for electrically powering the fluid delivery device; and

an electrostatic discharge protection system including at least one of: an electrically conductive static wick having a first end connected to an electrostatic charge accumulating component of the device and a second end exposed to atmosphere; a valve connected between a pump and the spray tip that is formed of nonconductive material; a barrier adjacent the fluid delivery device; a plurality of nonconductive components positioned to electrically isolate the spray tip from the fluid delivery device; or a nonconductive coating on a component of the control valve.

28. The handheld fluid dispensing device of claim **27** and further comprising a handle connected to the housing and positioned away from the spray tip.

29. The handheld fluid dispensing device of claim **28**, wherein the battery power source releasably connects to the handle.

30. The handheld fluid dispensing device of claim **28**, wherein the housing connects to a first end of the handle and the battery power source connects to a second end of the handle.

31. The handheld fluid dispensing device of claim **27**, wherein the plurality of nonconductive barriers are positioned near the battery power source to increase discharge travel distance.

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